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**Sato et al.**

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(54) **ASSEMBLY APPARATUS**

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***B64F 5/10*** (2017.01)

(52) **U.S. Cl.**
CPC ................ ***B23Q 15/06*** (2013.01); ***B64F 5/10*** (2017.01)

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(57) **ABSTRACT**

An assembly apparatus includes a retainer, a position measurement device, and a machining device. The retainer is configured to hold an assembly. The position measurement device is configured to measure a difference between an intended machining position and an actual machining position of a first coupling hole in a first assembly component. The first coupling hole is capable of being coupled to the assembly. The machining device is configured to form a second coupling hole capable of communicating with the first coupling hole in the assembly based on a reference position set on the assembly and the difference.

**2 Claims, 6 Drawing Sheets**

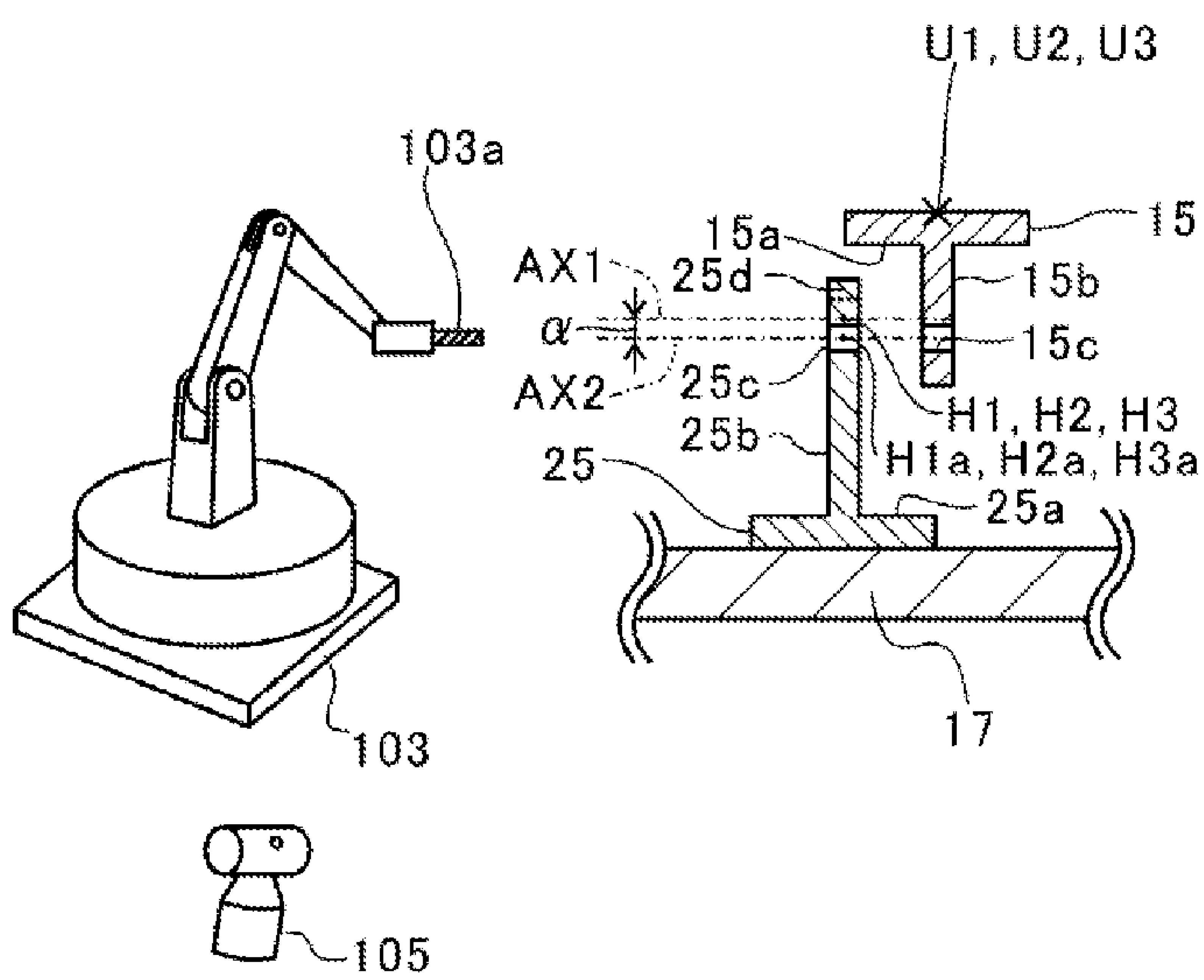

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FIG. 1

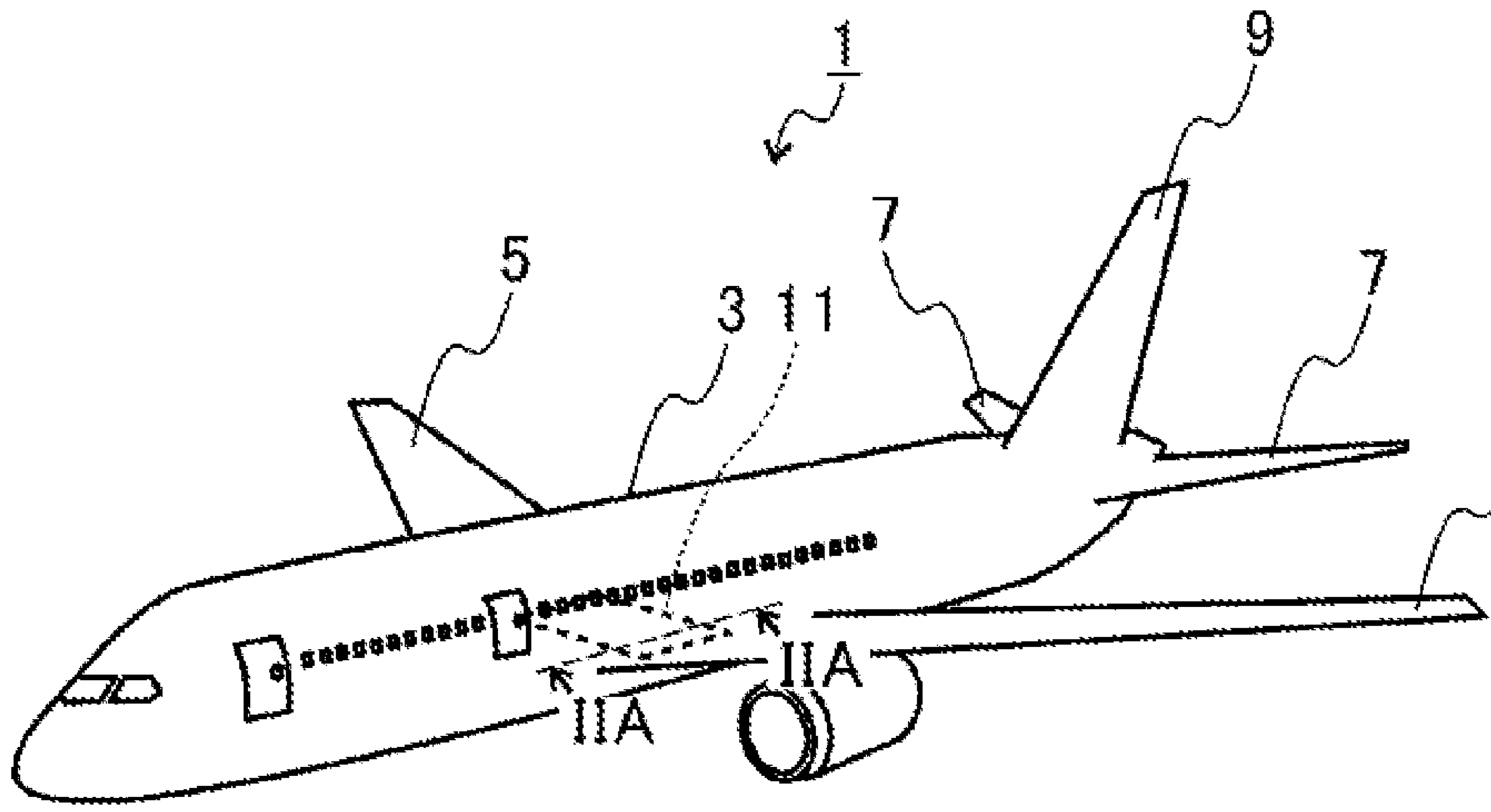


FIG. 2A

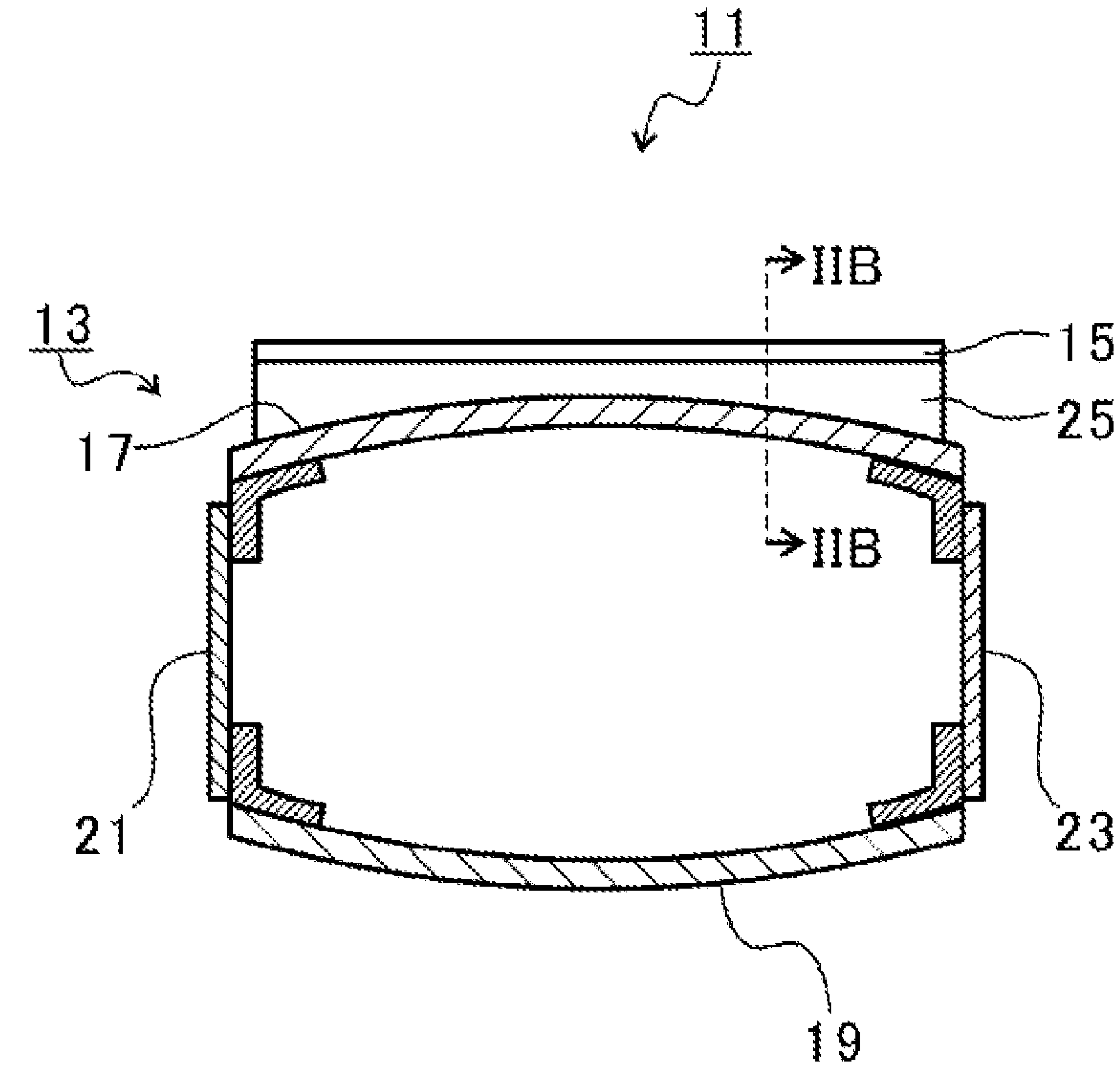



FIG. 2B

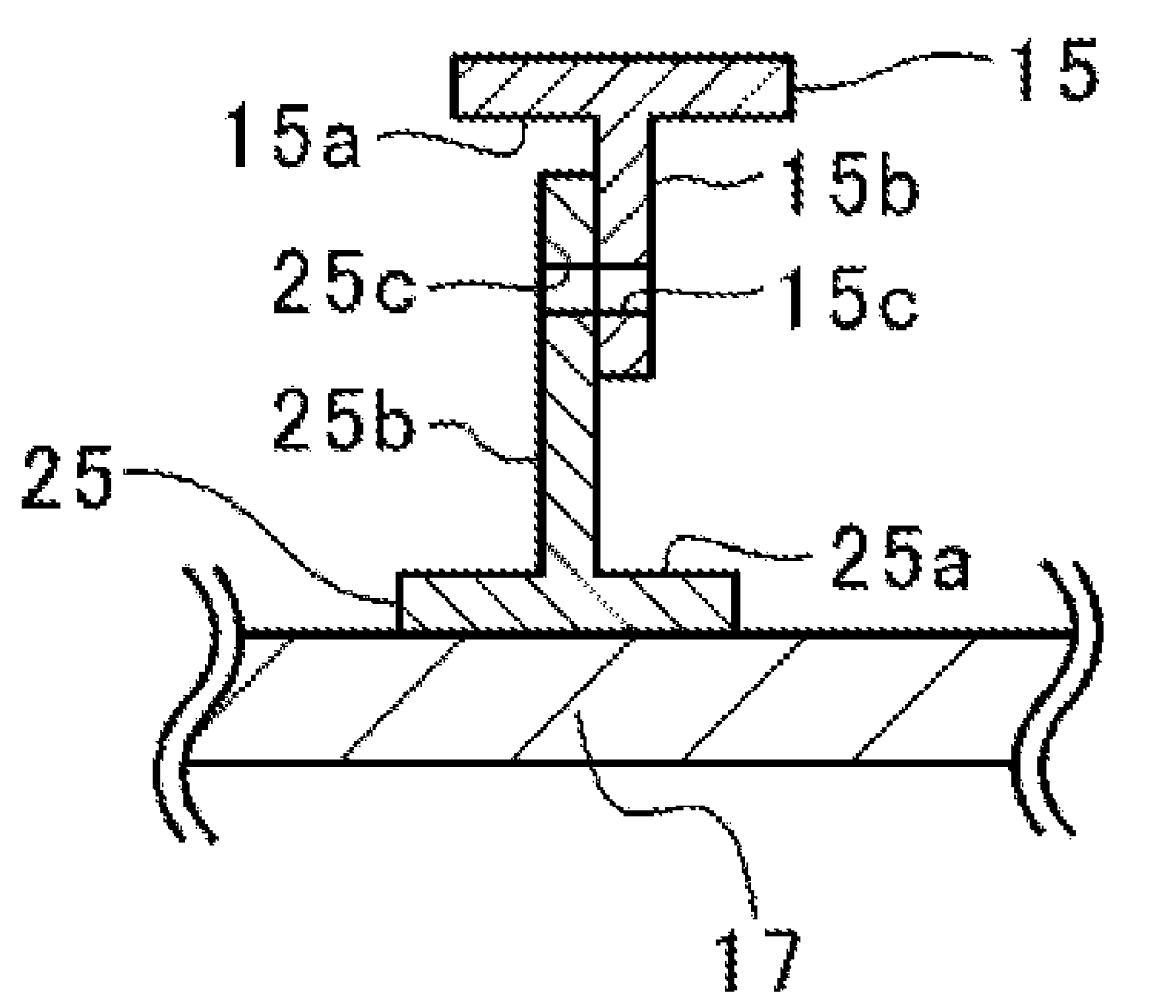


FIG. 3A

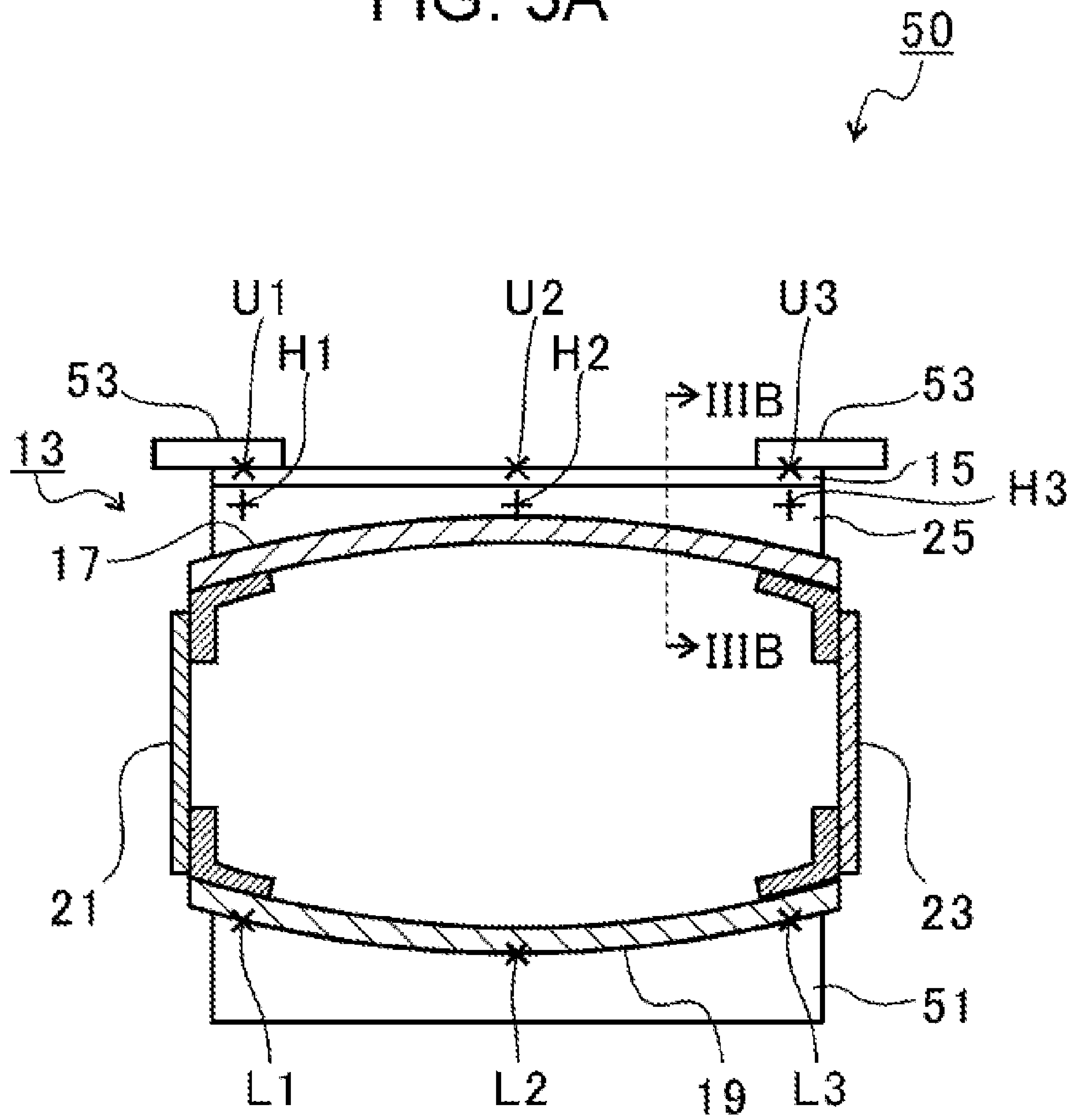

50
U1
U2
U3
H1
H2
53
→IIIB
53
13
15
H3
17
25
→IIIB
21
23
51
L1
L2
19
L3

FIG. 3B

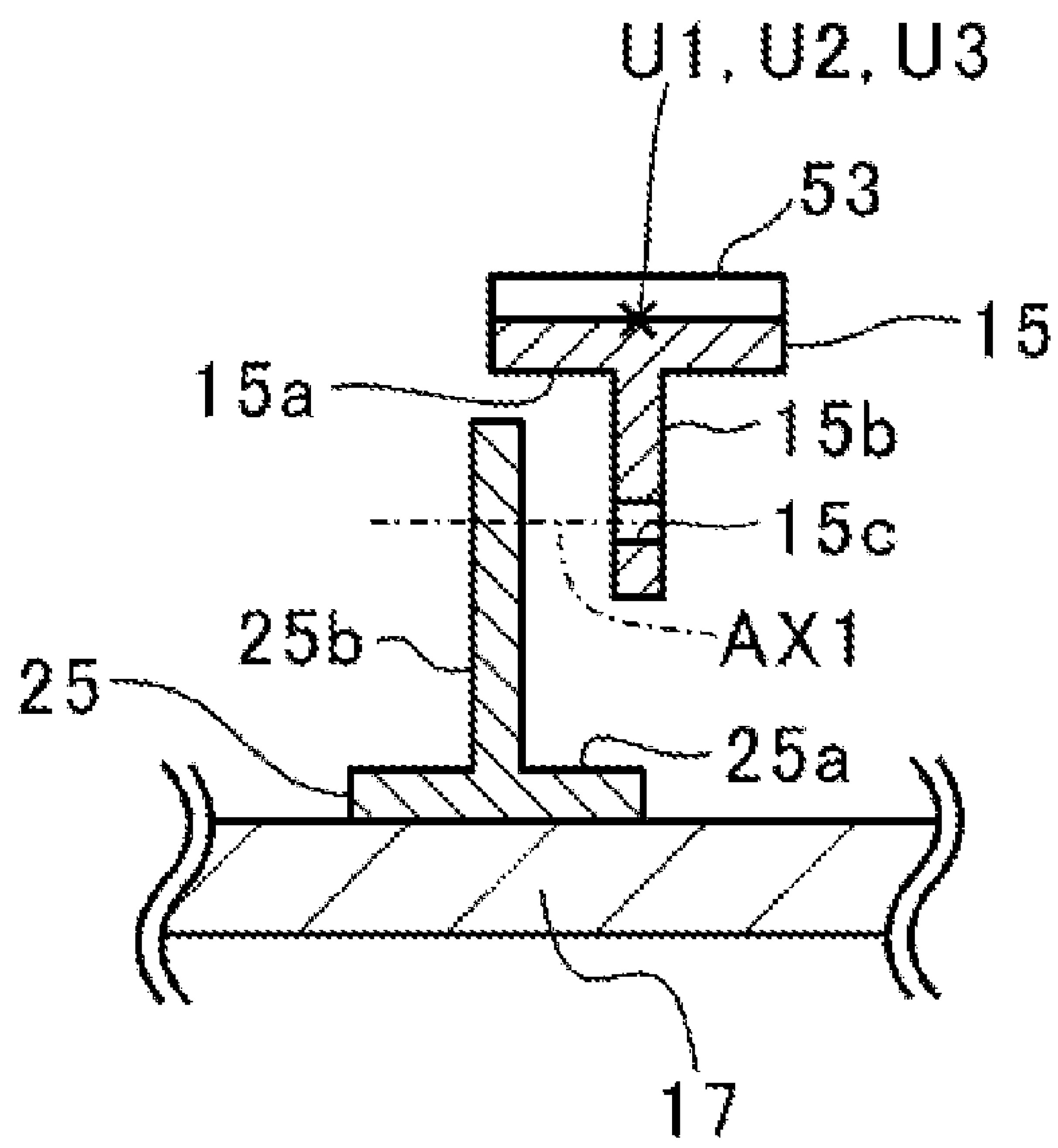

U1, U2, U3
53
15
15a
15b
15c
AX1
25b
25
25a
17

FIG. 4A

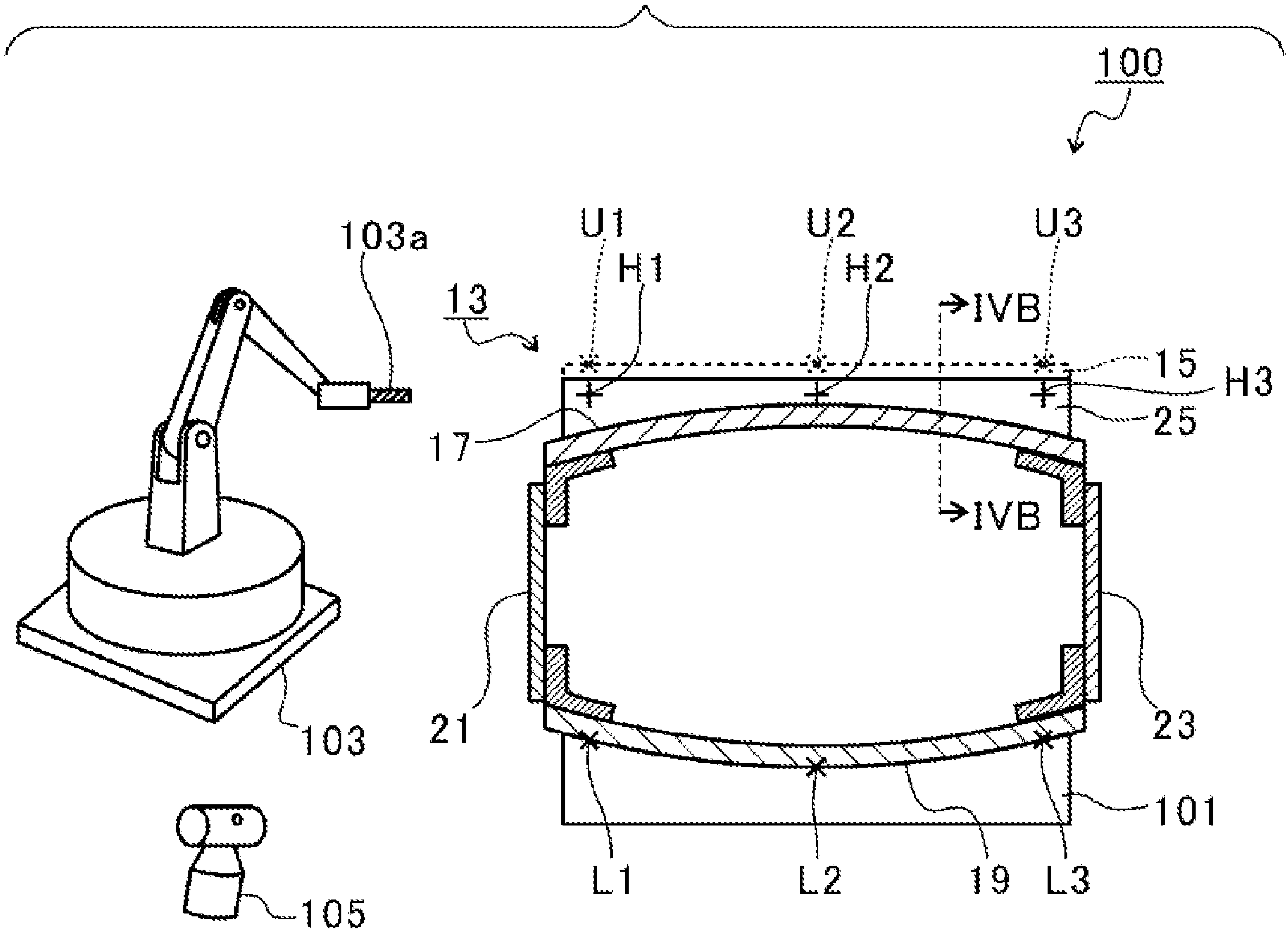

100
103a
13
U1
H1
U2
H2
U3
IVB
IVB
15
H3
25
17
21
23
103
101
105
L1
L2
19
L3

FIG. 4B

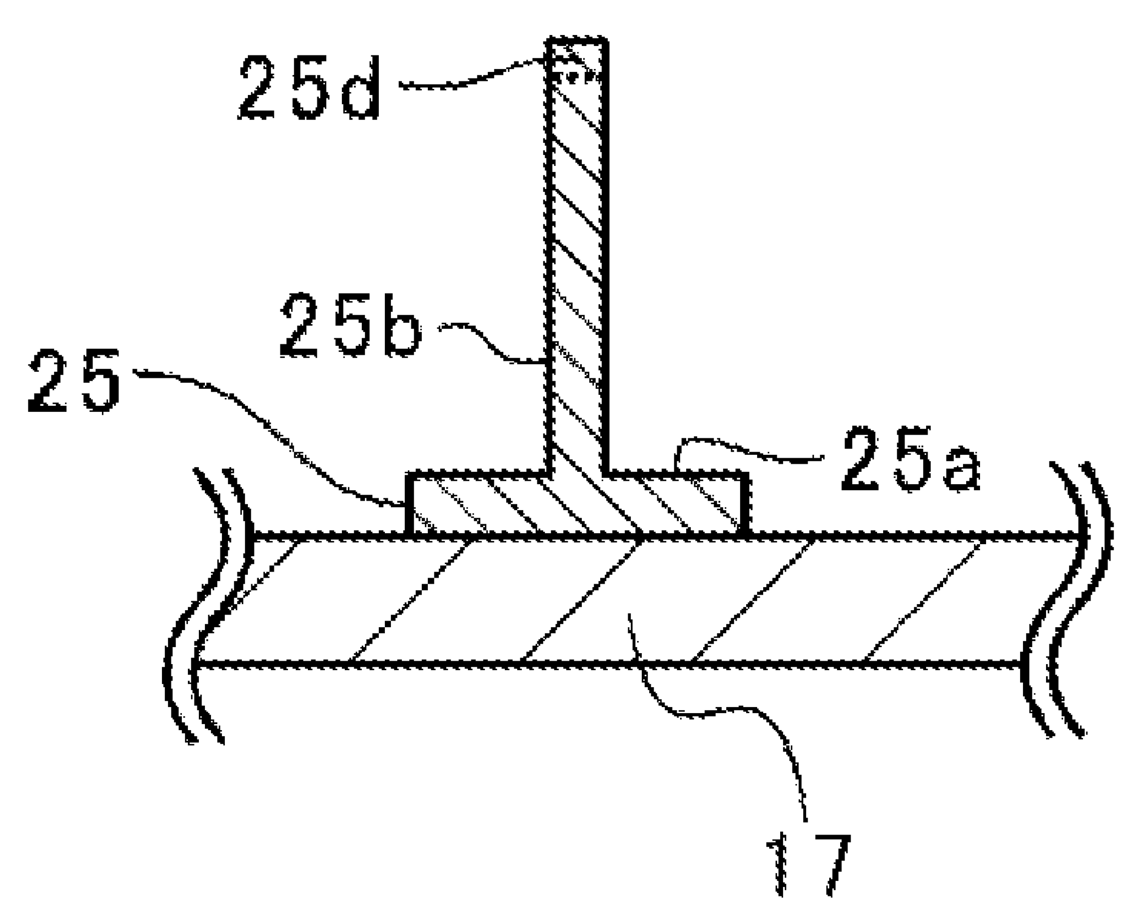

25d
25b
25
25a
17

FIG. 5A

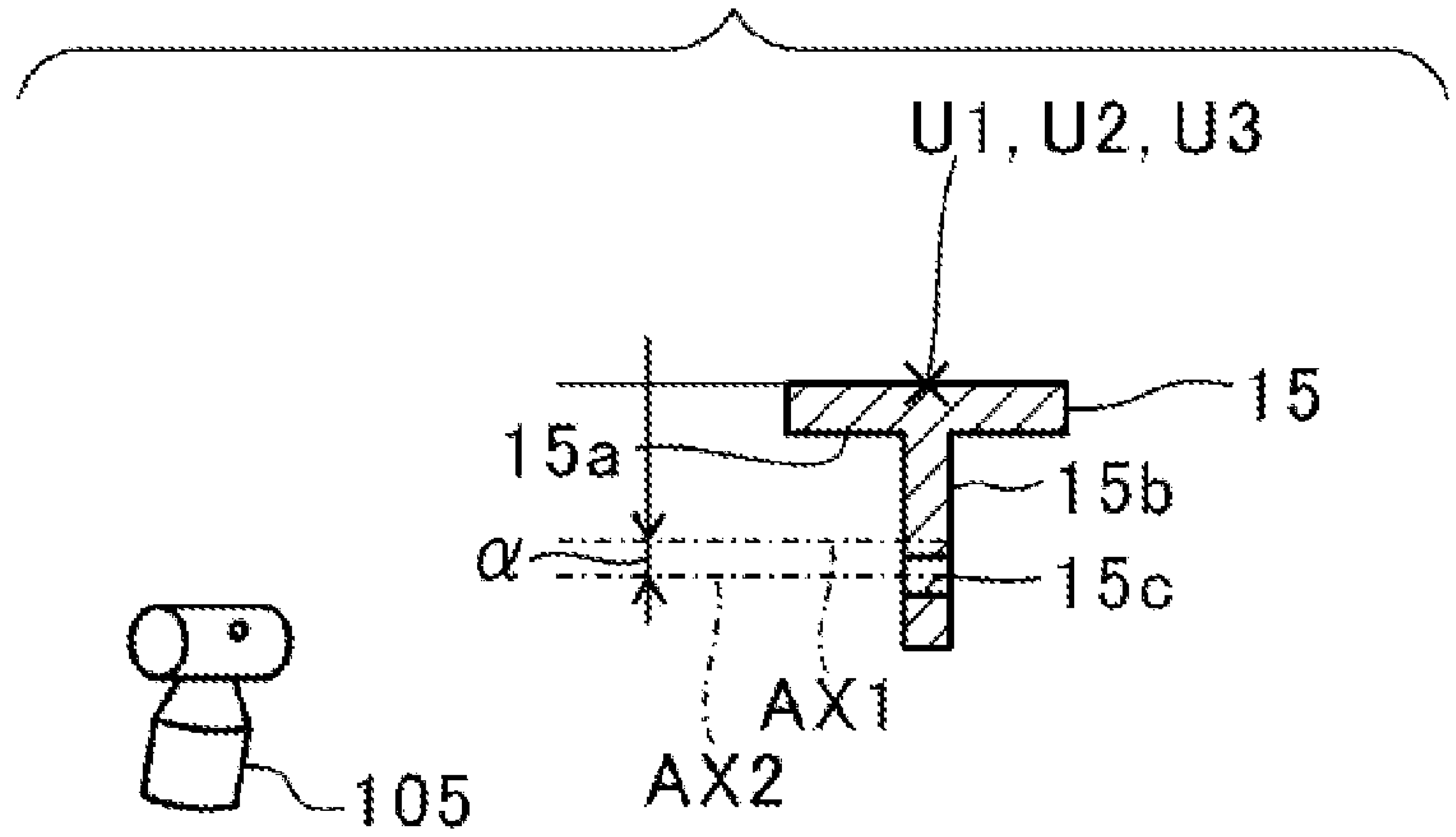

U1, U2, U3
15
15a
15b
α
15c
AX1
AX2
105

FIG. 5B

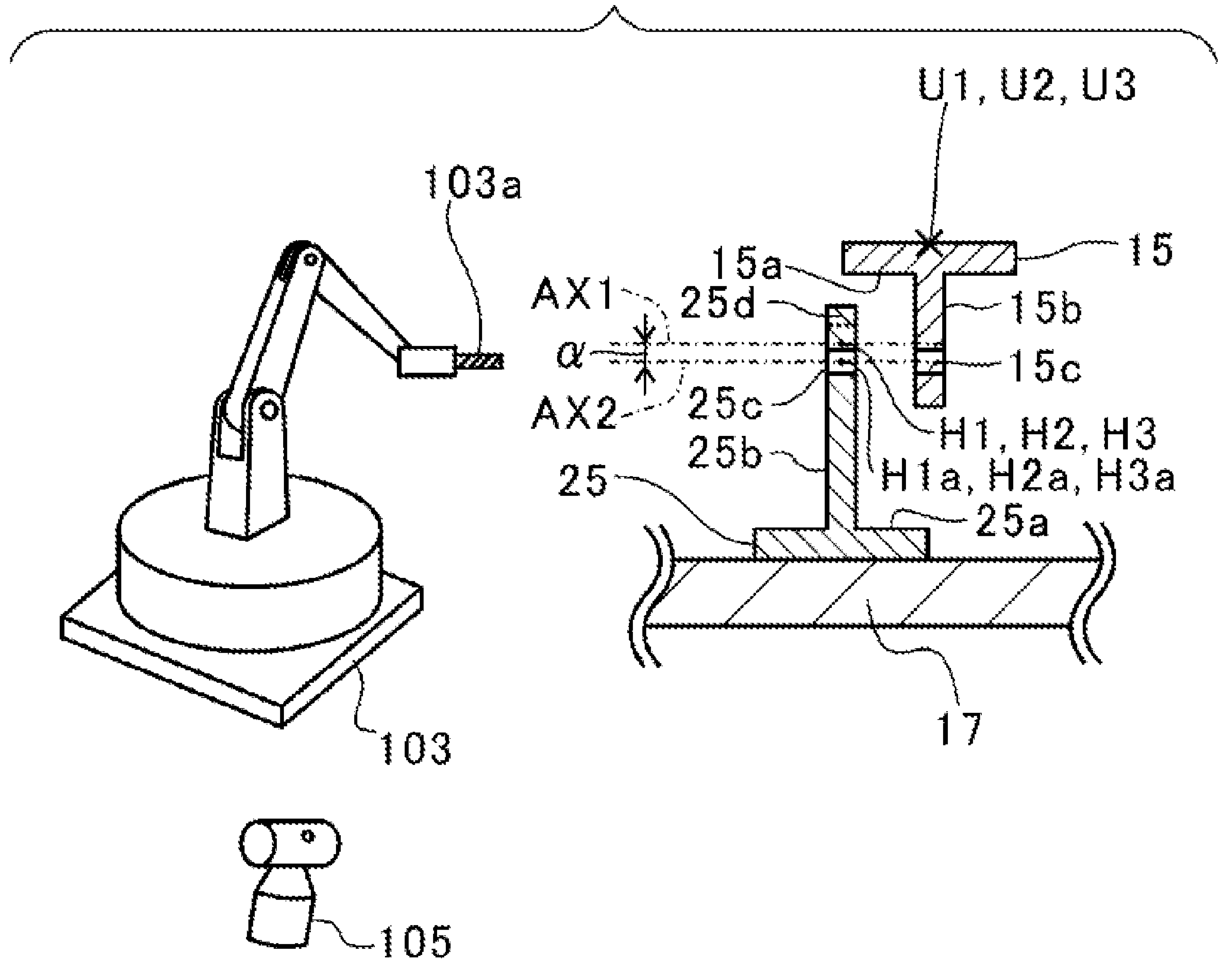
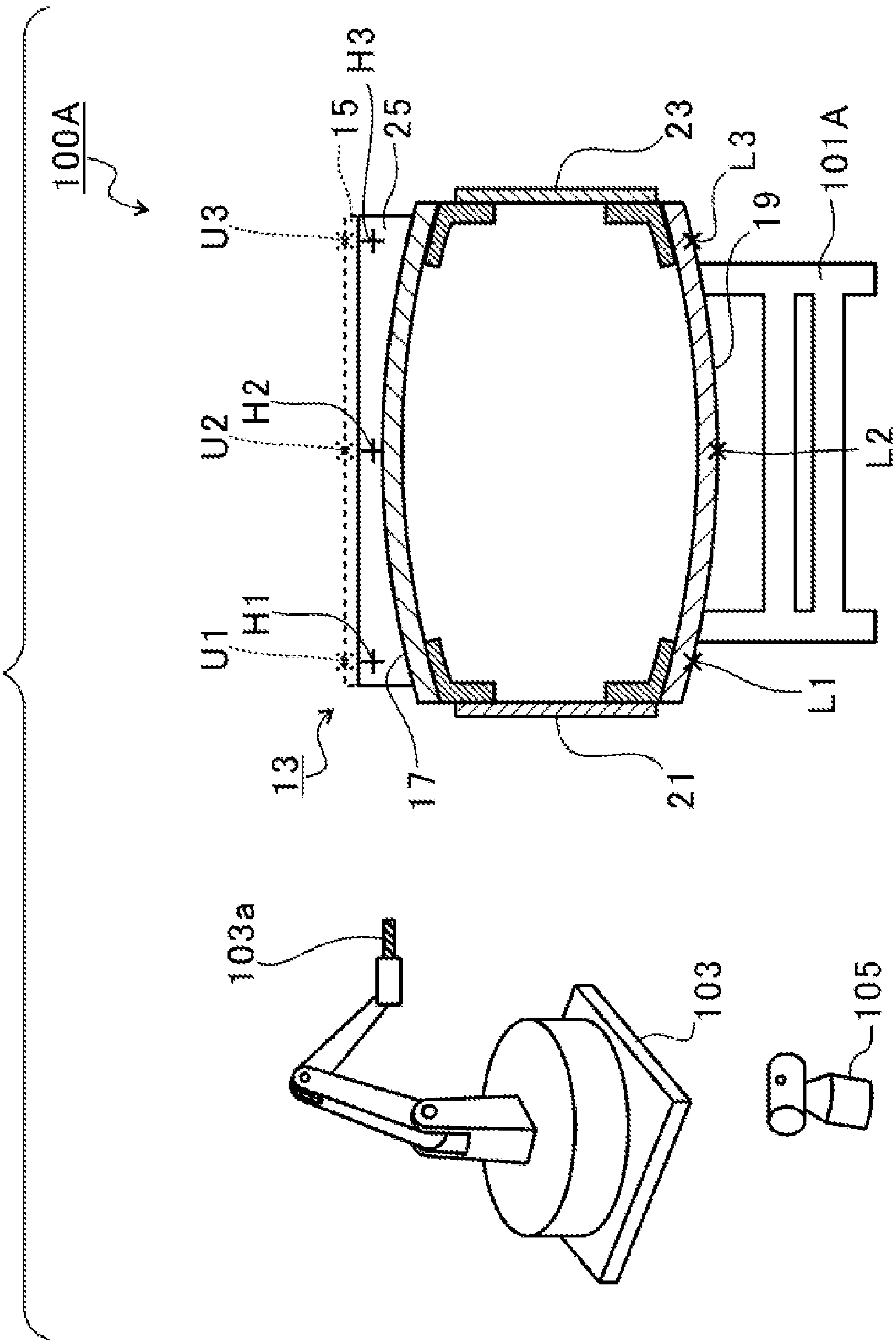

U1, U2, U3
103a
15a
15
AX1
25d
15b
α
15c
AX2
25c
H1, H2, H3
25b
H1a, H2a, H3a
25
25a
17
103
105

FIG. 6


100A
13
15
17
19
21
23
25
101A
103
103a
105
U1
U2
U3
H1
H2
H3
L1
L2
L3

# ASSEMBLY APPARATUS

## CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Japanese Patent Application No. 2019-204051 filed on Nov. 11, 2019, the entire contents of which are hereby incorporated by reference.

## BACKGROUND

The disclosure relates to an assembly apparatus.

A center wing of an aircraft includes a plurality of shaped steel materials having webs and flanges. Japanese Unexamined Patent Application Publication No. 2016-175157 discloses a drilling machine that drills a hole in a shaped steel material.

## SUMMARY

An aspect of the disclosure provides an assembly apparatus including a retainer, a position measurement device, and a machining device. The retainer is configured to hold an assembly. The position measurement device is configured to measure a difference between an intended machining position and an actual machining position of a first coupling hole in a first assembly component. The first coupling hole is capable of being coupled to the assembly. The machining device is configured to form a second coupling hole capable of communicating with the first coupling hole in the assembly on a basis of a reference position set on the assembly and the difference.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate an embodiment and, together with the specification, serve to explain the principles of the disclosure.

FIG. **1** is a schematic perspective view of an aircraft;

FIG. **2**A and FIG. **2**B schematically illustrate the structure of a center wing;

FIG. **3**A and FIG. **3**B schematically illustrate the structure of an assembly apparatus according to a comparative example;

FIG. **4**A and FIG. **4**B schematically illustrate the structure of an assembly apparatus according to an embodiment;

FIG. **5**A and FIG. **5**B illustrate a method for assembling the center wing according to the embodiment; and

FIG. **6** schematically illustrates the structure of an assembly apparatus according to a modification.

## DETAILED DESCRIPTION

According to the related art, a center wing is retained and positioned with jigs when a hole are drilled in a shaped steel material with a drilling machine. However, the jigs that retain and position the center wing are very expensive. Therefore, it is desirable to achieve both a reduction in the number of jigs and high assembly accuracy.

Thus, it is desirable to provide an assembly apparatus with which both a reduction in the number of jigs and high assembly accuracy can be achieved.

In the following, an embodiment of the disclosure is described in detail with reference to the accompanying drawings. Note that the following description is directed to an illustrative example of the disclosure and not to be construed as limiting to the disclosure. Factors including, without limitation, numerical values, shapes, materials, components, positions of the components, and how the components are coupled to each other are illustrative only and not to be construed as limiting to the disclosure. Further, elements in the following embodiment which are not recited in a most-generic independent claim of the disclosure are optional and may be provided on an as-needed basis. The drawings are schematic and are not intended to be drawn to scale. Throughout the present specification and the drawings, elements having substantially the same function and configuration are denoted with the same numerals to avoid any redundant description.



FIG. **1** is a schematic perspective view of an aircraft **1**. As illustrated in FIG. **1**, the aircraft **1** includes a fuselage **3**, a pair of main wings **5**, a pair of horizontal tails **7**, a vertical tail **9**, and a center wing **11**. In the following description, the main wings **5**, the horizontal tails **7**, the vertical tail **9**, and the center wing **11** may be referred to simply as wings and tails.

The fuselage **3** extends in a roll axis direction, which is the direction of a roll axis that connects nose and tail ends of the aircraft **1**. The main wings **5** are provided at the center of the fuselage **3** in the roll axis direction. The main wings **5** are arranged in a pitch axis direction, which is orthogonal to the roll axis direction, and provided on the left and right sides of the fuselage **3**. The main wings **5** extend outward from the fuselage **3** in the pitch axis direction. The main wings **5** have generates vertically upward lift for the aircraft **1**.

The horizontal tails **7** are disposed closer to the tail end of the fuselage **3** than the main wings **5** are. The horizontal tails **7** are arranged in the pitch axis direction and provided on the left and right sides of the fuselage **3**. The horizontal tails **7** extend outward from the fuselage **3** in the pitch axis direction. The horizontal tails **7** ensures stability of the aircraft **1** around the pitch axis.

The vertical tail **9** is disposed closer to the tail end of the fuselage **3** than the main wings **5** are. The vertical tail **9** extends outward from the fuselage **3** in a yaw axis direction, which is orthogonal to the roll axis direction and the pitch axis direction. The vertical tail **9** has ensures stability of the aircraft **1** around the yaw axis.

The center wing **11** is disposed (mounted) in the fuselage **3**. A cabin floor, for example, is disposed vertically above the center wing **11**, and a lower surface of the fuselage **3** is disposed vertically below the center wing **11**. Similar to the main wings, the center wing **11** is provided at the center of the fuselage **3** in the roll axis direction. The center wing **11** is coupled to the left and right main wings **5**, and functions as portions of the main wings **5**. The center wing **11** reduces deformation of the main wings **5** due to the lift.

FIG. **2**A and FIG. **2**B schematically illustrate the structure of the center wing **11**. FIG. **2**A is a schematic sectional view of the center wing **11** illustrated in FIG. **1** taken along line IIA-IIA. FIG. **2**B is a schematic sectional view taken along line IIB-IIB in FIG. **2**A.

As illustrated in FIG. **2**A, the center wing **11** includes an assembly **13** and a first shaped steel material (first assembly component) **15**. The center wing **11** has an integral structure including the assembly **13** and the first shaped steel material **15** and formed by fastening the assembly **13** and the first shaped steel material **15** together with fastening members (not illustrated), such as bolts. The cabin floor, for example, is placed vertically above the first shaped steel material **15**.

The assembly **13** has a box structure formed by assembling a plurality of assembly components. In this embodiment, the assembly **13** includes an upper panel **17**, a lower panel **19**, a front spar **21**, a rear spar **23**, and a second shaped steel material (second assembly component) **25**.

The upper panel **17**, which is a plate-shaped member, is disposed to face the lower panel **19** in the vertical direction. The lower panel **19**, which is also a plate-shaped member, is disposed vertically below the upper panel **17**. The upper panel **17** and the lower panel **19** are curved in this embodiment, but may instead be flat. The front spar **21** and the rear spar **23** are disposed between the upper panel **17** and the lower panel **19**.

The front spar **21**, which is a plate-shaped member, is disposed to face the rear spar **23** in a horizontal direction. The rear spar **23**, which is also a plate-shaped member, is disposed closer to the tail end than the front spar **21** is in the roll axis direction. The front spar **21** is coupled to the upper panel **17** and the lower panel **19** by coupling members, and the rear spar **23** is also coupled to the upper panel **17** and the lower panel **19** by coupling members. Thus, the upper panel **17**, the lower panel **19**, the front spar **21**, and the rear spar **23** are brought together to form a box shape.

The second shaped steel material **25** is positioned vertically above the upper panel **17**, and is fixed to the upper surface of the upper panel **17**. As illustrated in FIG. **2**B, the second shaped steel material **25** is T-shaped and includes a flange **25***a* and a web **25***b*. The flange **25***a* is coupled to the upper panel **17**, and the web **25***b* extends from the flange **25***a* in a direction away from the upper panel **17**. The web **25***b* has a coupling hole (second coupling hole) **25***c*. The coupling hole **25***c* extends through the web **25***b* in the thickness direction.

The flange **25***a* and the web **25***b* extend in the direction from the near side to the far side of FIG. **2**B. In other words, as illustrated in FIG. **2**A, the second shaped steel material **25** extends between the front spar **21** and the rear spar **23** in the roll axis direction.

The first shaped steel material **15** is positioned vertically above the flange **25***a* of the second shaped steel material **25**. As illustrated in FIG. **2**B, the first shaped steel material **15** is T-shaped, and the shape thereof is similar to that of the second shaped steel material **25**. The first shaped steel material **15** includes a flange **15***a* and a web **15***b*. The flange **15***a* is disposed to face the flange **25***a* of the second shaped steel material **25** in the vertical direction. The web **15***b* extends from the flange **15***a* in a direction toward the upper panel **17**. The web **15***b* is disposed such that at least a portion thereof overlaps the web **25***b* of the second shaped steel material **25** in the thickness direction (left-right direction in FIG. **2**B). The web **15***b* has a coupling hole (first coupling hole) **15***c*. The coupling hole **15***c* extends through the web **15***b* in the thickness direction.

The flange **15***a* and the web **15***b* extend in the direction from the near side to the far side of FIG. **2**B. In other words, as illustrated in FIG. **2**A, the first shaped steel material **15** extends between the front spar **21** and the rear spar **23** in the roll axis direction.

The coupling holes **15***c* and **25***c* are disposed to face each other in the thickness direction of the webs **15***b* and **25***b*. A fastening member (not illustrated) is inserted through the coupling holes **15***c* and **25***c* to fasten the first shaped steel material **15** and the second shaped steel material **25** (assembly **13**) together. Thus, the center wing **11** is assembled.

An assembly apparatus **50** for the center wing **11** according to a comparative example will now be described. FIG. **3**A and FIG. **3**B schematically illustrate the structure of the assembly apparatus **50** according to the comparative example. FIG. **3**A schematically illustrates the structure of the assembly apparatus **50** before the coupling hole **25***c* is formed in the second shaped steel material **25**, and FIG. **3**B is a schematic sectional view taken along line IIIB-IIIB in FIG. **3**A. As illustrated in FIG. **3**A, the assembly apparatus **50** includes a lower jig **51**, an upper jig **53**, and a drilling machine (not illustrated).

The lower jig **51** is disposed vertically below the lower panel **19**. The lower jig **51** retains the assembly **13** in an assembling position at a location vertically below the lower panel **19**. The upper jig **53** is disposed vertically above the first shaped steel material **15**. The upper jig **53** retains the first shaped steel material **15** in an assembling position at a location vertically above the first shaped steel material **15**.

As described above, the cabin floor, for example, is disposed vertically above the center wing **11**, and the lower surface of the fuselage is disposed vertically below the center wing **11**. Therefore, it is desirable that each coordinate of the center wing **11** is accurately positioned. The lower jig **51** has coordinates L**1**, L**2**, and L**3** for the design shape (design values) of the center wing **11** (assembly **13**). The lower jig **51** retains the assembly **13** so that the lower surface of the lower panel **19** is positioned at the coordinates L**1**, L**2**, and L**3** and that intended positional accuracy of the coordinates L**1**, L**2**, and L**3** can be achieved.

Similarly, the upper jig **53** has coordinates U**1**, U**2**, and U**3** for the design shape (design values) of the center wing **11** (first shaped steel material **15**). The upper jig **53** retains the first shaped steel material **15** so that the upper surface of the first shaped steel material **15** is positioned at the coordinates U**1**, U**2**, and U**3** and that intended positional accuracy of the coordinates U**1**, U**2**, and U**3** is achieved.

The drilling machine (not illustrated) forms (drills) the coupling hole **25***c* in the second shaped steel material **25** while the assembly **13** is retained by the lower jig **51** in the assembling position and the first shaped steel material **15** is retained by the upper jig **53** in the assembling position. In other words, the drilling machine (not illustrated) forms the coupling hole **25***c* in the second shaped steel material **25** while the lower surface of the lower panel **19** is positioned at the coordinates L**1**, L**2**, and L**3** and the upper surface of the first shaped steel material **15** is positioned at the coordinates U**1**, U**2**, and U**3**.

As illustrated in FIG. **3**B, the coupling hole **15***c* is formed in the first shaped steel material **15**. The drilling machine (not illustrated) forms the coupling hole **25***c* illustrated in FIG. **2**B in the second shaped steel material **25** by inserting a drilling tool (not illustrated) through the coupling hole **15***c* and moving the drilling tool along a central axis AX**1** of the coupling hole **15***c*.

The assembly apparatus **50** fastens the first shaped steel material **15** and the second shaped steel material **25** (assembly **13**) together by inserting a fastening member (not illustrated) through the coupling holes **15***c* and **25***c*. Thus, assembly of the center wing **11** is completed.

The assembly apparatus **50** assembles the center wing **11** while the intended positional accuracy of each of the coordinates L**1**, L**2**, L**3**, U**1**, U**2**, and U**3** is achieved by the jigs. Accordingly, the center wing **11** can be structured such that the intended positional accuracy of each coordinate is achieved. However, the lower jig **51** and the upper jig **53** used to achieve the intended positional accuracy of each coordinate are very expensive, and it is desirable to reduce the number of jigs. When the center wing **11** is assembled without using the jigs by using the assembly components as references, since the assembly components have allowable component errors and allowable assembly errors, it is difficult to achieve the intended positional accuracy of each coordinate, and the assembly accuracy is reduced. Thus, according to the comparative example, it is difficult to achieve both a reduction in the number of jigs and high assembly accuracy.

An assembly apparatus **100** according to the embodiment of the disclosure will now be described. FIG. **4**A and FIG. **4**B schematically illustrate the structure of the assembly apparatus **100** according to the embodiment. FIG. **4**A schematically illustrates the structure of the assembly apparatus **100** before the coupling hole **25***c* is formed in the second shaped steel material **25**, and FIG. **4**B is a schematic sectional view taken along line IVB-IVB in FIG. **4**A. As illustrated in FIG. **4**A, the assembly apparatus **100** includes a retainer **101**, a machining device **103**, and a position measurement device **105**.

The retainer **101** is, for example, a jig that is disposed vertically below the lower panel **19**. The retainer **101** retains the assembly **13** in an assembling position at a location vertically below the lower panel **19**. The retainer **101** has coordinates (reference positions) L**1**, L**2**, and L**3** for the design shape (design values) of the center wing **11** (assembly **13**). The retainer **101** retains the assembly **13** so that the lower surface of the lower panel **19** is positioned at the coordinates L**1**, L**2**, and L**3** and that intended positional accuracy of the coordinates L**1**, L**2**, and L**3** can be achieved.

The machining device **103** is, for example, a drilling machine and includes a drilling tool (tool) **103***a*. In this embodiment, the machining device **103** forms the coupling hole (through hole) **25***c* in the second shaped steel material **25** by rotating the drilling tool **103***a* with a motor (not illustrated).

The position measurement device **105** is, for example, a three-dimensional position measurement device that acquires three-dimensional position information by irradiating a three-dimensional object with laser light and measuring the amount of light reflected by the object. In this embodiment, the position measurement device **105** measures the tool position of the drilling tool **103***a* of the machining device **103** and the coordinates L**1**, L**2**, and L**3** of the retainer **101**. The machining device **103** controls the position of the drilling tool **103***a* based on the three-dimensional position information acquired by the position measurement device **105**.

As illustrated in FIG. **4**B, the second shaped steel material **25** of this embodiment has an excess portion **25***d*. In other words, the second shaped steel material **25** of this embodiment is shaped such that the length of the web **25***b* in the vertical direction is greater than the length of the web **25***b* of the comparative example in the vertical direction by the length of the excess portion **25***d*.

FIG. **5**A and FIG. **5**B illustrate a method for assembling the center wing **11** of this embodiment. FIG. **5**A illustrates measurement of the amount of displacement of the coupling hole **15***c* in the first shaped steel material **15** by the position measurement device **105**. FIG. **5**B illustrates formation of the coupling hole **25***c* in the second shaped steel material **25** by the machining device **103**.

As illustrated in FIG. **5**A, the position measurement device **105** measures coordinates U**1**, U**2**, and U**3** provided on the first shaped steel material **15** and a coordinate of the coupling hole **15***c* formed in the first shaped steel material **15** (for example, a coordinate of a central axis AX**2** of the coupling hole **15***c*).

The position measurement device **105** stores information regarding the design shape (design values) of the first shaped steel material **15** in a memory (storage), which is not illustrated. The design values of the first shaped steel material **15** include the coordinates U**1**, U**2**, and U**3** and an ideal coordinate of the central axis AX**1** of the coupling hole **15***c* set with respect to the coordinates U**1**, U**2**, and U**3**. In other words, the memory stores information regarding the design shape including an intended machining position of the first shaped steel material **15**. The position measurement device **105** measures the difference between the intended machining position stored in the memory and the actual machining position based on the acquired three-dimensional position information. For example, the position measurement device **105** determines the difference (hereinafter referred to as a component error) α between the coordinate of the central axis AX**1** and the coordinate of the central axis AX**2** with respect to the coordinates U**1**, U**2**, and U**3**.

As illustrated in FIG. **5**B, the machining device **103** forms the coupling hole **25***c* in the second shaped steel material **25** by using the coordinates L**1**, L**2**, and L**3** provided on the retainer **101** (see FIG. **4**A) as references. The machining device **103** stores information regarding the design shape (design values) of the assembly **13** (second shaped steel material **25**) in a memory (not illustrated). The design values of the assembly **13** include the coordinates L**1**, L**2**, and L**3** and ideal coordinates H**1**, H**2**, and H**3** (see FIG. **4**A) of the central axis of the coupling hole **25***c* set with respect to the coordinates L**1**, L**2**, and L**3**.

As illustrated in FIG. **5**B, the central axis AX**2** of the coupling hole **15***c* in the first shaped steel material **15** is displaced from the ideal central axis AX**1** of the coupling hole **15***c* set with respect to the coordinates U**1**, U**2**, and U**3**. When the machining device **103** drills a hole in the second shaped steel material **25** at the coordinates H**1**, H**2**, and H**3** by using the coordinates L**1**, L**2**, and L**3** as references, the central axis of the coupling hole **25***c* roughly coincides with the central axis AX**1**. Therefore, when the machining device **103** drills a hole at the coordinates H**1**, H**2**, and H**3** and when the first shaped steel material **15** and the second shaped steel material **25** are fastened together by inserting a fastening member (not illustrated) through the coupling holes **15***c* and **25***c*, the upper surface of the first shaped steel material **15** is displaced from the coordinates U**1**, U**2**, and U**3**.

Accordingly, the machining device **103** of this embodiment determines coordinates H**1***a*, H**2***a*, and H**3***a* based on the coordinates H**1**, H**2**, and H**3** and the component error α. For example, as illustrated in FIG. **5**B, the machining device **103** determines coordinates shifted from the coordinates H**1**, H**2**, and H**3** by the component error α as the coordinates H**1***a*, H**2***a*, and H**3***a*. Then, based on the three-dimensional position information acquired by the position measurement device **105**, the machining device **103** moves the drilling tool **103***a* to the coordinates H**1***a*, H**2***a*, and H**3***a* by using the coordinates L**1**, L**2**, and L**3** as references and then forms the coupling hole **25***c* in the second shaped steel material **25**.

Accordingly, the central axis of the coupling hole **25***c* roughly coincides with the central axis AX**2**. Therefore, when the first shaped steel material **15** and the second shaped steel material **25** are fastened together by inserting a fastening member (not illustrated) through the coupling holes **15***c* and **25***c*, the upper surface of the first shaped steel material **15** is positioned at the coordinates U**1**, U**2**, and U**3**, and the intended positional accuracy of the coordinates U**1**, U**2**, and U**3** can be achieved.

As described above, the assembly apparatus **100** of this embodiment measures the difference (component error α) between the intended machining position (central axis AX**1**) and the actual machining position (central axis AX**2**) of the coupling hole **15***c* that is formed in the first shaped steel material **15** and that is to be coupled to the assembly **13**. The assembly apparatus **100** forms the coupling hole **25***c* capable of communicating with the coupling hole **15***c* in the second shaped steel material **25** based on the reference positions (coordinates L**1**, L**2**, and L**3**) set on the assembly **13** and the component error α. Therefore, according to the assembly apparatus **100**, the intended positional accuracy of the coordinates L**1**, L**2**, L**3**, U**1**, U**2**, and U**3** can be achieved even when the center wing **11** is assembled without using the upper jig **53** illustrated in FIG. **3**A. As a result, both a reduction in the number of jigs and high assembly accuracy can be achieved.

In this embodiment, the machining device **103** forms the coupling hole **25***c* based on the tool position of the drilling tool **103***a* measured by the position measurement device **105** and the coordinates (reference positions) L**1**, L**2**, and L**3**. The drilling machine according to the comparative example determines the position at which a hole is to be drilled by using an encoder provided therein. In contrast, the machining device **103** of the embodiment of the disclosure forms the coupling hole **25***c* based on the three-dimensional position information acquired by the position measurement device **105**. Therefore, the accuracy of the drilling position is higher than that in the comparative example.

Modification

FIG. **6** schematically illustrates the structure of an assembly apparatus **100**A according to a modification. Components that are substantially the same as those in the above-described embodiment are denoted by the same reference numerals, and description thereof is omitted. As illustrated in FIG. **6**, the assembly apparatus **100**A according to the modification includes a retainer **101**A having a structure different from that of the retainer **101** according to the above-described embodiment. Other structures are the same as those of the assembly apparatus **100** according to the above-described embodiment, and description thereof is thus omitted.

According to the above-described embodiment, the retainer **101** is a jig. The modification differs from the above-described embodiment in that the retainer **101**A is not a jig. The retainer **101**A is, for example, a table. The table is designed so that the intended positional accuracy of the coordinates L**1**, L**2**, and L**3** is achieved when the assembly **13** is placed thereon. Therefore, when the assembly **13** is placed on the table, the lower surface of the lower panel **19** is positioned at the coordinates L**1**, L**2**, and L**3**, and the intended positional accuracy of the coordinates L**1**, L**2**, and L**3** can be achieved.

As described above, the assembly apparatus **100**A according to the modification includes the table as the retainer **101**A. Since the table is provided, the center wing **11** can be accurately assembled without using a jig. Thus, according to the modification, not only can the operations and effects similar to those of the above-described embodiment be obtained, the number of jigs can be further reduced from that in the above-described embodiment.

The retainer **101**A may have any structure as long as the intended positional accuracy of the coordinates L**1**, L**2**, and L**3** can be achieved when the assembly **13** is placed thereon, and may be, for example, a movable carrier. When the retainer **101**A is a movable carrier, the retainer **101**A can be moved while the assembly **13** is retained in the assembling position. Therefore, according to the assembly apparatus **100**A, the center wing **11** can be more efficiently assembled.

Although an embodiment of the disclosure has been described above with reference to the accompanying drawings, it goes without saying that the disclosure is not limited to the above-described embodiment. It is clear that a person skilled in the art can arrive at various alterations and modifications within the scope described in the claims. It is to be understood that these alterations and modifications are, of course, included in the technical scope of the disclosure.

In the above-described embodiment and modification, the assembly apparatuses **100** and **100**A assemble the center wing **11**. However, the assembly apparatuses **100** and **100**A are not limited to this, and may assemble other wings or tails. For example, the assembly apparatuses **100** and **100**A may instead assemble the main wings **5**, the horizontal tails **7**, or the vertical tail **9**.

In the above-described embodiment and modification, the machining device **103** controls the position of the drilling tool **103***a* based on the three-dimensional position information acquired by the position measurement device **105**. However, the machining device **103** is not limited to this, and may instead control the position of the drilling tool **103***a* by using an encoder mounted therein.

The invention claimed is:

**1**. An aircraft wing assembly apparatus for fastening a first assembly component to an assembly, the first assembly component including a first coupling hole through which a fastening member for the fastening is insertable, the assembly apparatus comprising:
- a first retainer configured to hold the first assembly component in a first position when performing the fastening, the first retainer comprising a first portion that indicates a first reference position;
- a second retainer configured to hold the assembly in a second position when performing the fastening, the second retainer comprising the second position when performing the fastening, the second retainer comprising a second reference portion that indicates a second reference position;
- a drilling machine comprising a robot arm that holds a drilling tool and configured to form a second coupling hole through which the fastening member is insertable in the assembly by using the drilling tool; and
- a laser scanner configured to measure a three-dimensional position of a three-dimensional object,

wherein the laser scanner is configured to:
- store a first intended machining position of the first coupling hole and a second intended machining position of the second coupling hole, the first intended machining position is defined relative to the first reference position, the second intended machining position is defined relative to the second reference position;
- in a state where the first assembly component is held by the first retainer, measure a three-dimensional position of the first reference portion and an actual machining position of the first coupling hole;
- calculate a difference between the measured actual machining position of the first coupling hole and the stored first intended machining position of the first coupling hole, and

wherein the drilling machine is configured to:
- determine a target position shifted from the stored second intended machining position of the second coupling hole by the calculated difference; and
- in a state where the assembly is held by the second retainer, form the second coupling hole in the assembly by moving the drilling tool to the determined target position based on the measured relative posi-

tion of the drilling tool and the measured three-dimensional position of the second reference portion.

**2**. The aircraft wing assembly apparatus according to claim **1**, wherein the laser scanner is positioned in a fixed position relative to a base of the robot arm.

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